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ENVIRONMENTAL MONITORING REPORT

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

OAK RIDGE FACILITIES

Calendar Year 1974

UNION CARBIDE

NUCLEAR DIVISION
OAK RIDGE, TENNESSEE

prepared for the **U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION**
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US ERDA OAK RIDGE FACILITIES, CY 1974

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ENVIRONMENTAL MONITORING REPORT

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

OAK RIDGE FACILITIES

Calendar Year 1974

UNION CARBIDE CORPORATION - NUCLEAR DIVISION
Oak Ridge Gaseous Diffusion Plant
Holifield National Laboratory
Oak Ridge Y-12 Plant

Office of Safety and Environmental Protection
Post Office Box Y
Oak Ridge, Tennessee 37830

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INTRODUCTION

Oak Ridge is located in East Tennessee in a broad valley which lies between the Cumberland Mountains on the northwest and the Great Smoky Mountains on the southeast. The Energy Research and Development Administration (ERDA) Reservation is located in the Valley and Ridge physiographic province which is characterized by parallel ridges of sandstone, shale, and cherty dolomite, separated by valleys of less weather-resistant limestone and shale. The ridges are oriented southwest-northeast. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 740 feet to 1360 feet above mean sea level with a maximum relief of 620 feet. The area includes gently sloping valleys and rolling to steep slopes and ridges. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form the southern and western boundaries of the Reservation while the City of Oak Ridge (approximately 28,000 population) is on the northern boundary.

The local climate is noticeably influenced by topography. Prevailing winds are usually either up-valley, from west to southwest, or down-valley, from east to northeast. During periods of light winds, daytime winds are usually southwesterly and nighttime winds usually northeasterly. Wind velocities are somewhat decreased by the mountains and ridges, and tornadoes rarely occur. In winter, the Cumberland Mountains have a moderating influence on the local climate by retarding the flow of cold air from the north and west. Temperatures of 100°F or higher and 0°F or below are unusual. Low-level temperature inversions occur during approximately 56 percent of the hourly observations. Winter and early spring are the seasons of heaviest precipitation with the monthly maximum normally occurring during January to March. The mean annual precipitation is approximately 54 inches.

The topography of the Oak Ridge Area is such that all drainage from the ERDA Reservation flows into the Clinch River which has its headwaters in southwestern Virginia and flows southwest to its mouth near Kingston, Tennessee. The Clinch River flow is regulated by several dams which provide reservoirs for flood control, electric power generation, and recreation. The principal tributaries through which liquid effluents from the plant areas reach the Clinch River are White Oak Creek, East Fork Poplar Creek, and Poplar Creek.

With the exception of the City of Oak Ridge, the land within 5 miles of the ERDA Reservation is predominantly rural being utilized largely for residences, small farms, and pasturage for cattle. The approximate location and population of the towns nearest the ERDA Reservation are: Oliver Springs (pop. 3400) 7 miles to the northwest; Clinton (pop. 4800) 10 miles to the northeast; Lenoir City (pop. 5300) 7 miles to the southeast; Kingston (pop. 4100) 7 miles to the southwest; and Harriman (pop. 8700) 8 miles to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 25 miles to the east and has a population of approximately 175,000.

The ERDA Reservation contains three major operating facilities: the Holifield National Laboratory (HNL), the Oak Ridge Gaseous Diffusion Plant (ORGDP), and the Y-12 Plant; all of which are operated by Union Carbide Corporation, Nuclear Division. In addition, two smaller ERDA facilities are in the area: the Comparative Animal Research Laboratory, and Oak Ridge Associated Universities.

The Holifield National Laboratory is a large multipurpose research laboratory whose basic mission is the discovery of new knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, the Laboratory conducts research in all fields of modern science and technology. The Laboratory's facilities consist of nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is a complex of production research, development, and support facilities located west of the city of Oak Ridge. While the primary function of ORGDP is the enrichment of uranium hexafluoride (UF_6) in the uranium-235 isotope, extensive efforts are also expended on research and development activities associated with both the gaseous diffusion and gas centrifuge processes. In addition, the barrier material used by all three Energy Research and Development Administration-owned gaseous diffusion plants is manufactured at ORGDP. Numerous other activities (maintenance, nitrogen production, steam production, uranium recovery, fluorine production, water treatment, laboratory analysis, administration, etc.) lend support to these primary functions and are thus essential to the operation of this plant.

The Oak Ridge Y-12 Plant which is located immediately adjacent to the City of Oak Ridge has four major responsibilities: (1) production of nuclear weapon components, (2) fabrication support for weapon design agencies, (3) support for the Holifield National Laboratory, and (4) support and assistance to other government agencies. Activities associated with these functions include the production of lithium compounds, the recovery of enriched uranium from unirradiated scrap material, and the fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Operations associated with the ERDA research and production facilities in Oak Ridge give rise to several types of waste materials.

Radioactive wastes are generated from nuclear research activities, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive wastes are generated by normal industrial-type support operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plant operations, and steam plant operations.

Nonradioactive solid wastes are buried in a centralized sanitary landfill or designated burial areas. Radioactive solid wastes are buried in designated burial areas or placed in

retrievable storage either above or below ground depending upon the type and quantity of radioactive material present and the economic value involved.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques prior to release to the atmosphere. The major gaseous waste streams are released through stacks to provide atmospheric dilution for materials which may remain in the stream following treatment.

Liquid radioactive wastes are not released but are concentrated and contained in tanks for ultimate disposal. Process water which may contain small quantities of radioactive or chemical pollutants is discharged, after treatment, to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear Creek, which are small tributaries to the Clinch River.

SUMMARY

The Environmental Monitoring Program for the Oak Ridge area includes sampling and analysis of air, water from surface streams, several food products, vegetation, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1974.

Surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than 1% of the permissible concentration and intake guides for individuals in the offsite environment. While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.

The total body dose to a "hypothetical maximum exposed individual" at the site boundary was calculated to be 7.7 mrem/yr which is 1.5% of the ERDA Manual Chapter 0524 standard. The maximum dose to the critical organ of an individual from the aquatic food chain was calculated to be 5.4 millirem to the bone which is 1.1% of the allowable standard. The maximum dose to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 0.13 mrem/yr to the total body and 4.8 millirem to the lung. These doses are 0.03% and 0.3%, respectively, of the standards. The average dose to an Oak Ridge resident (the critical population group) was calculated to be 0.004 mrem/yr to the total body and 0.17 millirem to the lung as compared to approximately 100 mrem/yr from natural background radiation. The cumulative total body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1974 effluents was calculated to be 10 man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation.

Surveillance of nonradioactive materials in the Oak Ridge environs shows that established limits were not exceeded for those materials possibly present in the air as a result of plant operations with the exception of fluorides which exceeded the limits on several occasions. Pollution control projects are in progress to reduce fluoride emissions. The ORGDP steam plant was out of compliance with State emission limits for particulates, visible emissions, and occasionally sulfur dioxide during the winter months when coal was used as a supplemental fuel. Engineering studies are in progress to evaluate potential corrective measures should low sulfur coal not be available and a proposed FY1976 project now before Congress provides for the installation of electrostatic precipitators for particulate removal.

The chemical water quality data obtained from the water sampling program indicated compliance with standards with the exception of chromium, nitrates, pH, and dissolved oxygen. Environmental protection projects are in progress or under consideration to bring these parameters into compliance. Sewage treatment plants at HNL and ORGDP currently do not meet Federal secondary treatment requirements. Projects to provide secondary treatment at these facilities are expected to be completed during the next fiscal year.

MONITORING DATA
COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1974 are summarized in Tables 1 through 24. In general, the data tables show the number of samples collected at each location, the maximum concentration, the minimum concentration, the average concentration, the relevant standard, and percent of standard for the average of each parameter. Averages are usually accompanied by plus-or-minus ($\pm$) values which represent the 95% confidence limits. The 95% confidence limits which are calculated from the standard deviation of the average, assuming a normal frequency distribution, are predictions of the variability in the range of concentrations based on a limited number of measurements. They do not represent the conventional error in the average of repeated measurements on identical samples. Data which are below the minimum detectable limit are expressed as less than (<) the minimum detectable value. In computing average values, sample results below the detection limit are assigned the detection limit value with the resulting average value being expressed as less than (<) the computed average value.

Average concentrations are compared with environmental standards, where such standards have been established, as a means of evaluating the impact of effluent releases. In some cases, for lack of an official standard, stream concentrations of nonradioactive pollutants have been compared with U. S. Public Health Service Drinking Water Standards even though the streams are not a source of drinking water.

Air Monitoring

Radioactive — Atmospheric concentrations of radioactive materials occurring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of nine stations (HP-31 through HP-39) which encircle the perimeter of the Oak Ridge area and provides data for evaluating releases from Oak Ridge facilities to the immediate environment, Figure 1. A second system consists of eight stations (HP-51 through HP-58) encircling the Oak Ridge area at distances of from 12 to 75 miles, Figure 2. This system provides background data to aid in evaluating local conditions. Sampling for radioactive particulates is carried out by passing air continuously through filter papers. Filter papers are evaluated by gross beta and gross alpha counting techniques for normal operations. More detailed analyses are performed if concentrations in the environment are significantly above normal. Airborne radioactive iodine is monitored in the immediate environment (HP-31 through HP-39) by passing air continuously through cartridges containing activated charcoal. Charcoal cartridges are evaluated for radioactive iodine by gamma spectrometry.

Data on the concentrations of radioactive materials in air and the quantities of radioactive materials released to the atmosphere in the Oak Ridge and surrounding areas are given in Tables 1 through 4.

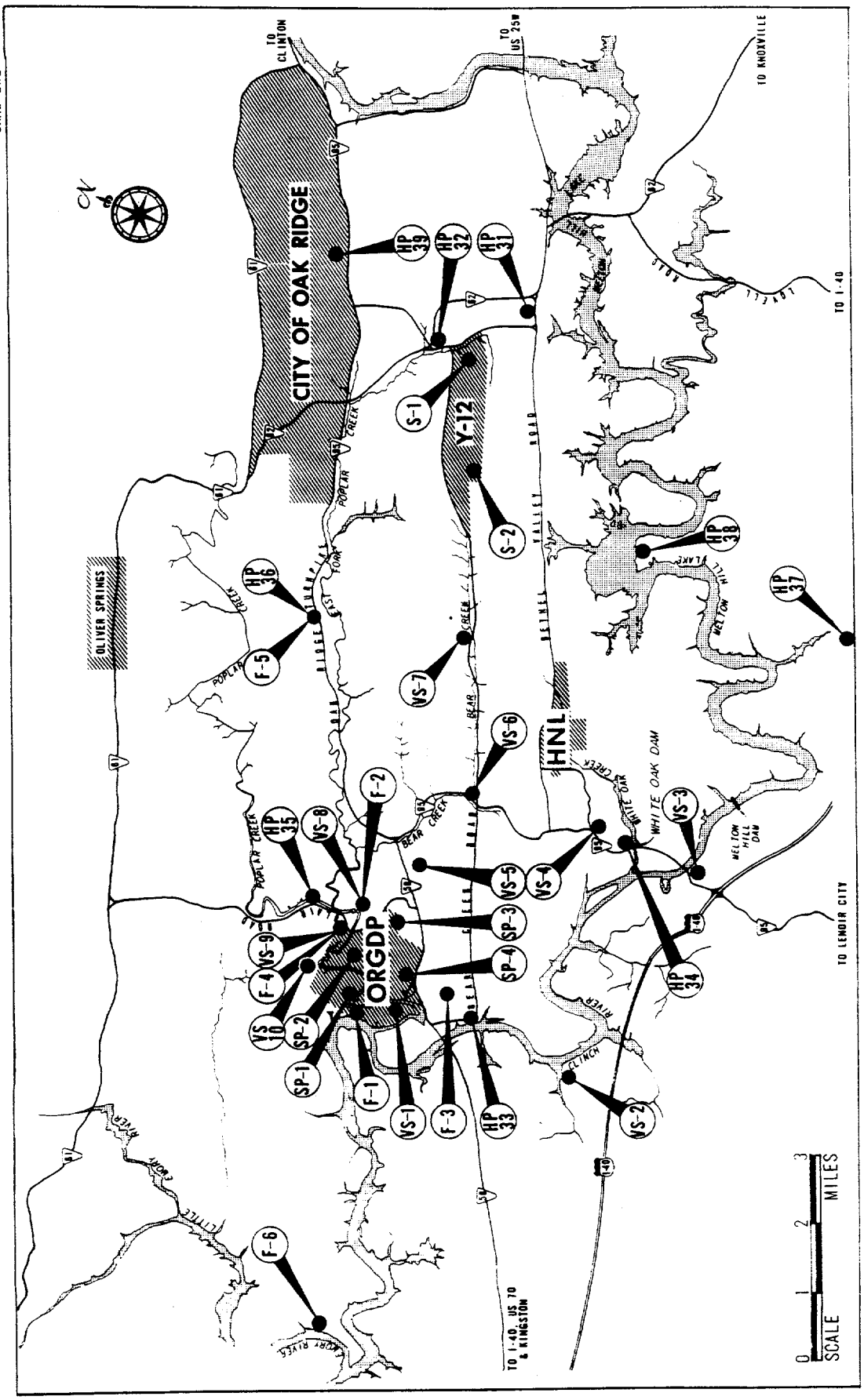

Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

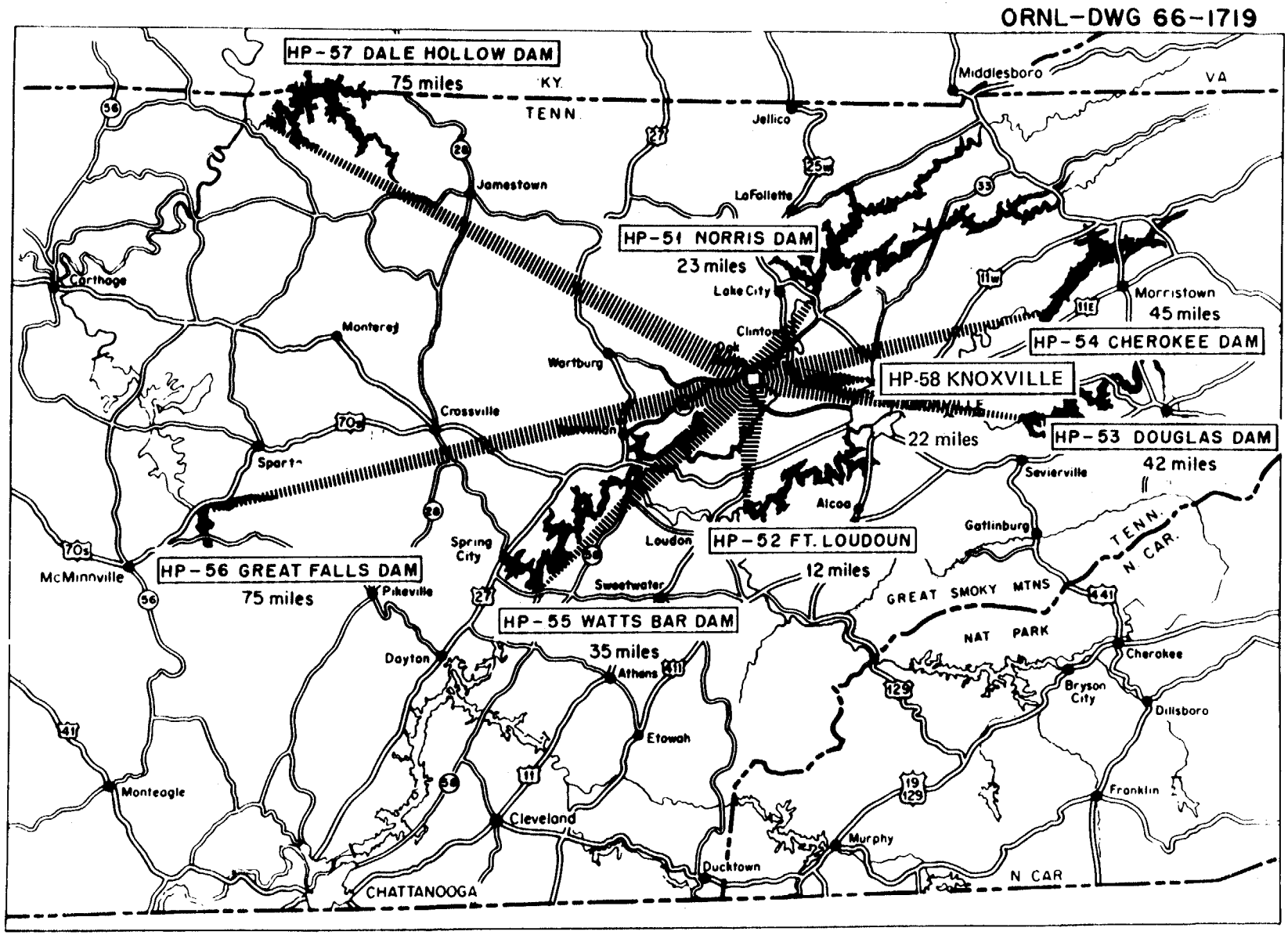

Figure 2

REMOTE AIR MONITORING LOCATIONS

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.08% of the applicable concentration guide (CG) as specified in the ERDA Manual, Appendix 0524,[1] for individuals in uncontrolled areas (Table 1). These average values measured for 1974 are higher than those for 1973 by a factor of approximately three. This increase was due primarily to a significant increase in the gross beta concentrations measured at all stations in both systems during the period March 1974 through mid-August 1974. Gamma spectrometry analysis of filter samples during this period indicated the activity to be due predominantly to ^{103}Ru, ^{141}Ce, and ^{95}Zr-^{95}Nb.

An increase in the concentrations of particulate radioactivity in air was detected at locations in both the eastern and western United States during the same period by the air monitoring network operated by the National Environmental Research Center-Las Vegas (NERC-LV) and by the Environmental Radiation Ambient Monitoring System (ERAMS).[2] Gamma spectrometric analyses of samples collected in May by NERC-LV identified the radionuclides ^{106}Ru, ^{95}Zr, and ^{141}Ce, and their presence was attributed to seasonal variations in world fallout.[3]

The average gross alpha concentrations in both the perimeter and remote monitoring systems were 0.03% of the CG for a mixture of uranium isotopes (Table 2).

The concentration of ^{131}I as measured by the perimeter air monitoring system was $< 0.01\%$ of the inhalation concentration guide for individuals in uncontrolled areas (Table 3).

While some radioactivity was released to the atmosphere (Table 4), measurements in the Oak Ridge area show that environmental levels were well below established standards. The detection of higher than normal levels of particulate radioactivity in other parts of the United States coincident with the occurrence of increased levels in both the immediate and remote environs of the Oak Ridge area strongly indicates that the radioactivity measured at Oak Ridge was principally of non-Oak Ridge origin.

Nonradioactive — Environmental air samples are taken for the determination of fluorides, suspended particulates, and sulfur dioxide.

Sampling locations for fluorides are indicated by F-1 through F-6, Figure 1. Concentrations in the ppb range are determined by collecting 24-hour samples in caustic solution in a Boyce-Thompson type sampler on an eight day frequency and analyzing the resulting solution by specific ion electrode.

Suspended particulates are measured at locations SP-1 through SP-4, Figure 1. The method for the determination of suspended particulates is the high volume method recommended by EPA. Particles are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity controlled atmosphere and

the filter is reweighed. From the weight of particulates, the sampling time, and the air flow rate, the particulate concentration in micrograms per cubic meter is calculated. The sampling period is 24 hours.

Two continuous monitoring stations (S-1 and S-2) were installed in the Y-12 Plant area for the measurement of ambient concentrations of sulfur dioxide. Limited data were collected from Station S-2 during the year due to multiple operational problems with the instrumentation and are not included in this report. Each station consists of a flame photometric continuous analyzer and recorder with associated equipment located in a temperature controlled shelter. Sulfur dioxide concentrations are interpreted on an hourly basis and averaged for 24 hour, monthly, and annual periods.

Air Monitoring data for fluorides, suspended particulates, and sulfur dioxide are presented in Tables 5 through 7. These data indicate that average environmental concentrations of particulates and sulfur dioxide were in compliance with applicable standards[4] during calendar year 1974. Fluoride concentrations exceeded the standards on several occasions. However, the high concentration of fluorides at Station F-6, which is five miles from Oak Ridge operations, indicate that the ambient fluoride background levels are generally high in the area and make interpretation of the incremental addition from Oak Ridge operations somewhat difficult. Several abatement projects have been initiated in the last year to reduce fluoride emissions. The majority of these projects are due to be completed by the end of FY1976.

Steam plant operations were in compliance with State emission limits except for the steam plant at ORGDP. The gaseous emissions for the ORGDP steam plant do not comply with Tennessee standards for particulates and SO_2 when coal is burned. The particulate standard states that no more than 0.5 pound of particulates may be discharged for each one million Btu's of heat input. The latest measurement of the ORGDP steam plant effluent indicates that 0.8 to 1.0 pound of particulates is released for each one million Btu's input when coal is burned. Similarly, the gaseous effluent from this facility also exceeds the 1.60 pounds of SO_2 per one million Btu's by 0.04 pound per one million Btu's when 1.1% sulfur coal is burned. Engineering studies are in progress to evaluate potential corrective measures should low sulfur coal not be available. A proposed FY1976 project now before Congress provides for the installation of electrostatic precipitators for particulate removal.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at seven of the perimeter air monitoring stations and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters are collected and analyzed on an approximate monthly frequency.

Data on the average external gamma radiation background rates are given in Table 8. The slight difference between the average levels in the perimeter and remote environs is considered to be within the variation in background levels normally experienced in East

Tennessee which is dependent upon elevation, topography, and geological character of the surrounding soil.[5]

External gamma radiation measurements were performed in a special survey along the stream course of Bear Creek and East Fork Poplar Creek to evaluate radioactivity which might be contained in the sediments as a result of effluent releases. Additionally, measurements were made along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream to evaluate gamma radiation levels resulting from effluent releases and sky shine from an experimental ^{137}Cs plot located near the river bank. Measurements were made using thermoluminescent dosimeters suspended one meter above the ground surface. The average background level determined at the perimeter stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

Gamma levels along Bear Creek ranged from 2 to 3 μR/hr above background, while levels along East Fork Poplar Creek ranged from 2 to 12 μR/hr above background. The external gamma radiation levels along the bank of the Clinch River ranged from 0 to 32 μR/hr above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were evaluated and are included, where significant, in the dose assessment section of the report.

A helicopter radiation survey of the Oak Ridge area was performed in November 1974. This survey was part of an ongoing nationwide program (Aerial Radiological Measuring System, ARMS) to determine external radiation levels around existing and proposed nuclear facilities. Approximately 10% of the continental United State's land area has been surveyed to date, primarily with fixed wing aircraft. The November flights verified the absence of offsite radioactivity attributable to ERDA operations other than those discussed above or previously quantified in past studies.

Water Monitoring

Radioactive — Water samples are collected in the Clinch River for radioactivity analyses at Melton Hill Dam (Station C-2) 2.3 miles above White Oak Creek outfall, at the ORGDP sanitary water intake (Station C-3) 6.3 miles downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, and at Center's Ferry (Station C-5) near Kingston, Tennessee (Figure 3). Samples are collected continuously at all locations except for Station C-5 which are collected on a grab-sample basis daily. Grab samples at Station C-5 are deemed adequate since day-to-day variations in concentration should be minimal due to the hydrology of the reservoir system and the distance downstream from Oak Ridge operations. Samples are composited for monthly or quarterly analysis depending upon location.

Water samples also are collected for radioactivity analyses at White Oak Dam (Station W-1), at the outlet of New Hope Pond on East Fork Poplar Creek (Station E-1), in Bear Creek (Station B-1), and in Poplar Creek (Stations P-1 and P-2), Figure 3. The samples collected

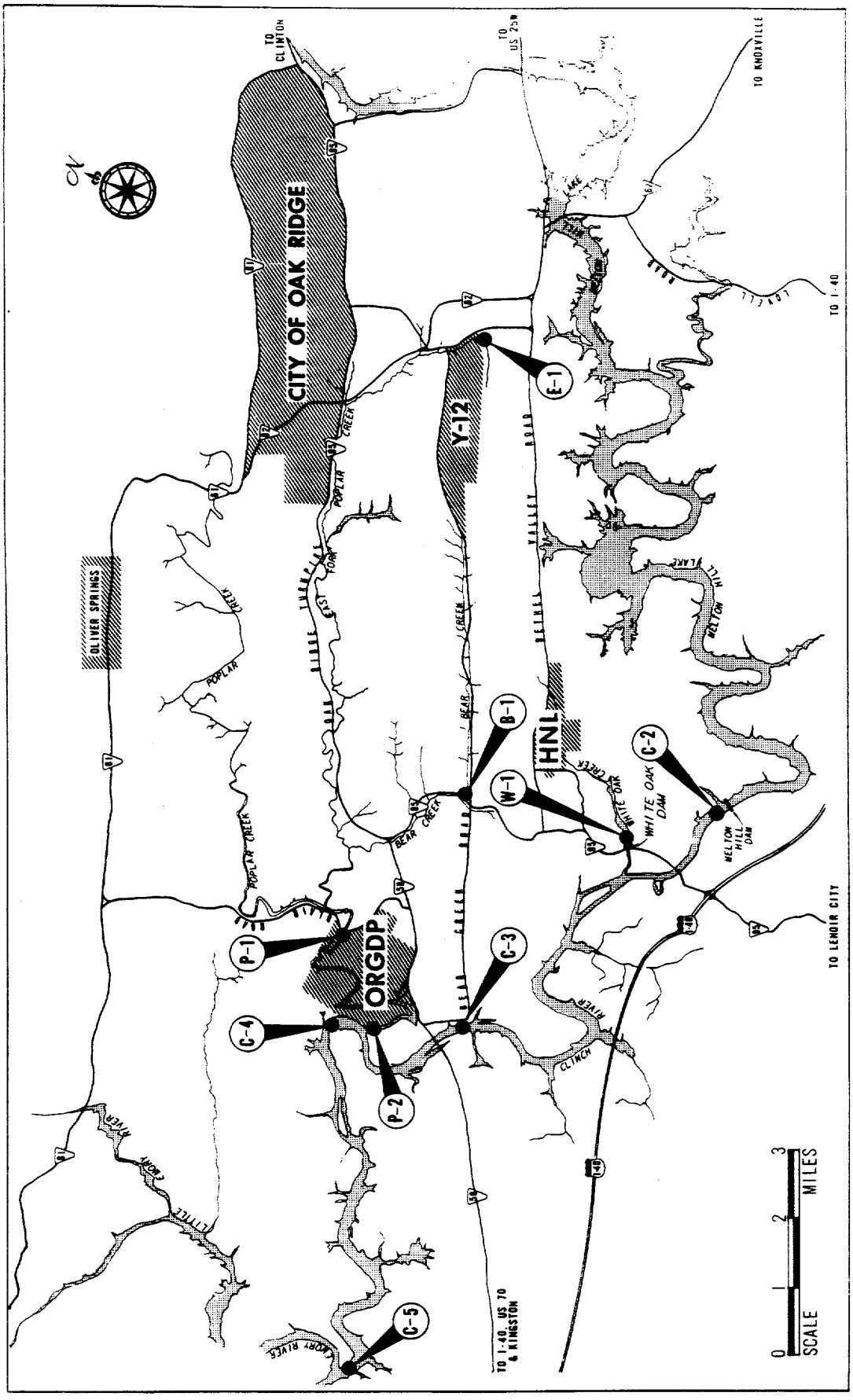

Figure 3
STREAM MONITORING LOCATIONS

at Stations W-1, E-1, and B-1 are continuous proportional samples. Samples collected at Stations P-1 and P-2 are weekly grab samples. Continuous samplers have been installed at Stations P-1 and P-2 but are not yet operational. All samples are composited for monthly analysis.

The concentrations of fission product radionuclides present in detectably significant amounts are determined by specific radionuclide analysis and gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective concentration guide (CG) value as specified in the ERDA Manual, Appendix 0524, and percent of concentration guide for a known mixture of radionuclides is calculated in accordance with the method given in Appendix 0524.

Data on the concentrations of fission product radionuclides, uranium in surface streams, and the quantities of radioactivity released to surface streams are given in Tables 9 through 11. The average concentrations of specific radionuclides in offsite surface streams at all points of measurement were less than 1% of the applicable concentration guides for uncontrolled areas.

The average concentration of transuranic alpha emitters in the Clinch River at Clinch River Mile (CRM) 20.8 resulting from effluent releases was 2.2×10^{-12} μCi/ml, which is less than 0.01% of the concentration guide for water containing a known mixture of radionuclides.*

Nonradioactive – Water samples are collected for the analysis of nonradioactive substances at the same locations discussed previously under radioactive water sampling. All samples are composited for monthly analysis. Samples are analyzed for a variety of anions and cations related to process release potential and background information needs by analytical procedures recommended by the Environmental Protection Agency.[6]

Data on the concentrations of various anions and cations in surface streams are given in Tables 12 through 19. The average concentrations of all substances analyzed were in compliance with drinking water standards[7] except for chromium at Station W-1 and nitrates at Station B-1. Pollution control projects are underway to reduce concentrations of these substances to levels below the standards.

Dissolved oxygen (DO) and pH measurements are made continuously at White Oak Dam (Station W-1) and continuous pH measurements are made at the outfall of New Hope Pond (Station E-1). Dissolved oxygen measurements are made weekly at Station E-1 with a direct reading instrument.

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*CG determined by method given in ERDA Manual, Appendix 0524 for determining the concentration guide for a known mixture of radionuclides.

Measurements of dissolved oxygen and pH at White Oak Dam indicated DO values ranging from 5 to > 15 mg/l and pH values from 6.5 to 9.4. The dissolved oxygen was in compliance with the State standard[8] while the pH was out of compliance with the State standard on 30 separate occasions. The high pH values at White Oak Dam were the result of natural changes and unrelated to HNL operations.

Measurements of dissolved oxygen and pH at the outfall of New Hope Pond indicated DO values ranging from 3.4 to 8.5 mg/l and pH values ranging from 6.2 to 9.2. The dissolved oxygen was out of compliance with the State standard on 21 occasions. A project is under way to provide aeration in New Hope Pond to increase the DO level. The pH measurements at the outfall of New Hope Pond were out of compliance on 40 occasions. This high incidence of pH non-compliance was attributed to a change in cooling tower treatment in 1974 which removed chromium from the blowdown, thus increasing algae growth in the pond which increased the pH level of the New Hope Pond discharge. Several possible solutions to this problem are under consideration.

Sewage treatment plants at HNL and ORGDP currently do not meet the new Federal secondary treatment requirements. Projects to provide secondary treatment at these facilities are expected to be completed during the next fiscal year.

Food Sources

Milk Monitoring – Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of Oak Ridge. Samples are normally collected weekly at each of eight stations located near the Oak Ridge area. However, milk sampling Station Number 8 was inoperative during 1974. Four stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 4 and 5. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to intake guides specified by the Federal Radiation Council (FRC).[9]

The average concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 20 and 21. If one assumes the average intake of milk per individual to be one liter per day, the average concentration of ^{131}I in the milk in both the immediate environs of the Oak Ridge area and in the environs remote from Oak Ridge is within FRC Range I. The average concentrations of ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range I. The concentration of ^{90}Sr in milk is different at different locations; part of the variation has been found to result from differences in farming methods used at different farms. Pastureland that is not fertilized and is overgrazed (a not too uncommon practice in this area) apparently results in a higher than normal concentration of ^{90}Sr in milk from cows pastured on this land.

Fish Sampling – Two species of fish which are commonly caught and eaten—white crappie and carp—are taken from the Clinch River during the spring and summer of each year. The fish are prepared for radiochemical analysis in a manner analogous to human utilization.

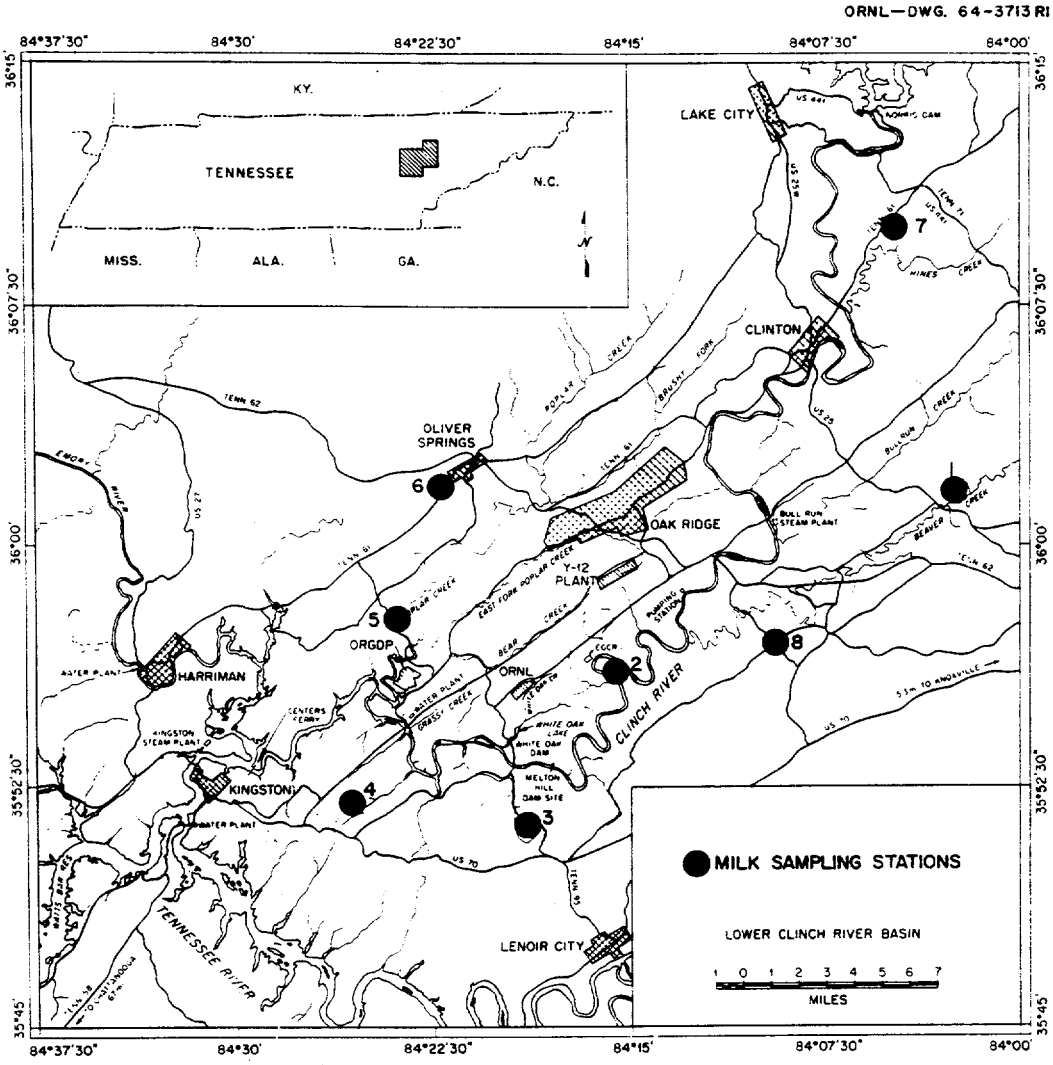

Figure 4
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

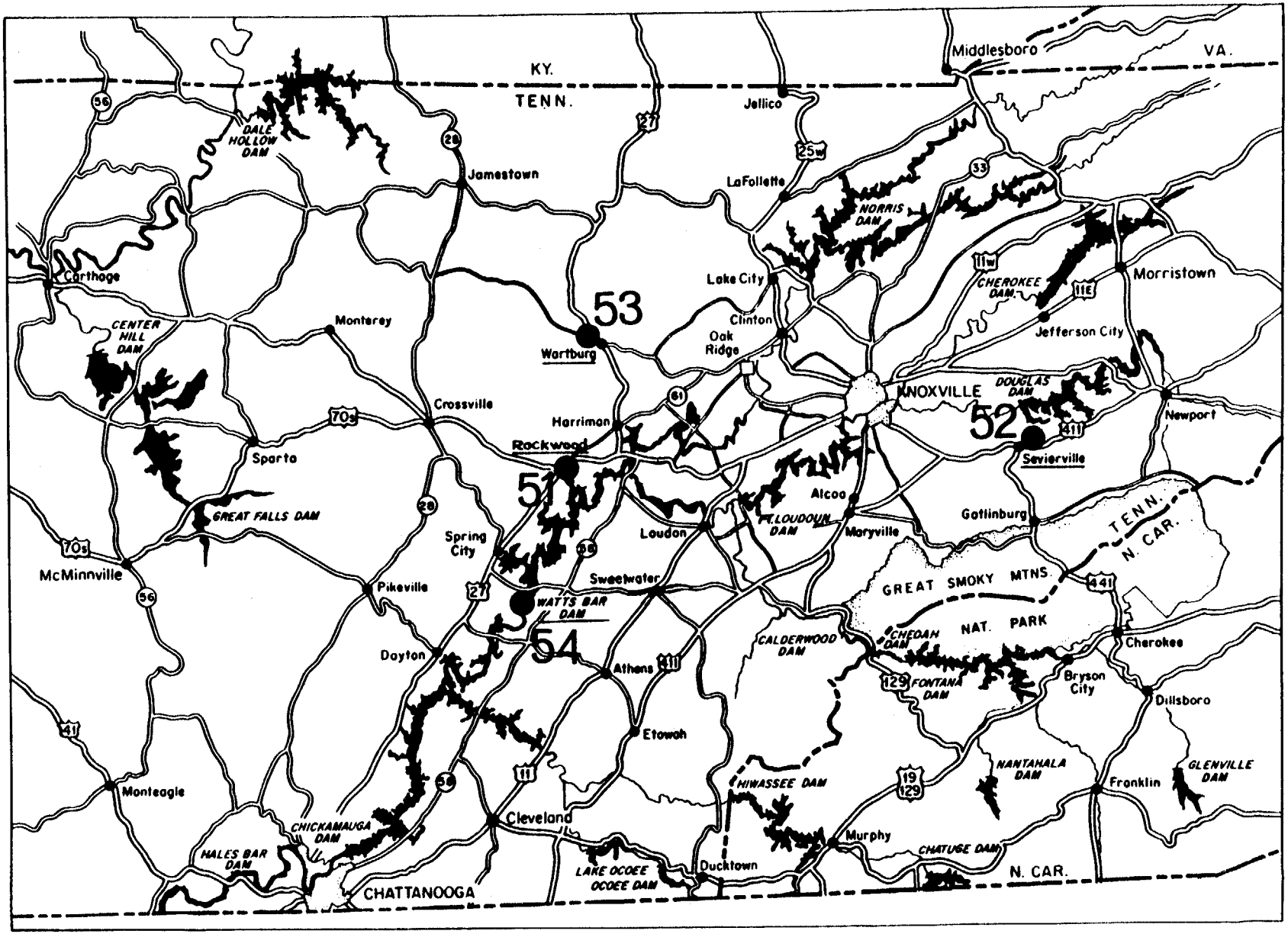

Figure 5

REMOTE ENVIRONS MILK SAMPLING LOCATIONS

The scales, head, and entrails are removed from the fish before cooking. The crappie are pan fried, and the bones are removed before the flesh is assayed. The carp are cooked in a pressure cooker, the bones and skin are removed, and both the flesh and juices are assayed for radioactivity. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Data on the concentrations of radionuclides in Clinch River fish are given in Table 22. Consumption of 37 pounds of fish per year[10] results in less than 1% of the maximum permissible intake. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question.

Vegetation and Soil

Vegetation – Samples of pine needles and grass were collected during the summer from 10 areas (Stations VS-1 through VS-10, Figure 1) and analyzed for uranium and fluoride content. Fluorometric analysis is used for the determination of uranium and colorimetric analysis is used for the determination of fluorides.

Data on the uranium and fluoride content in vegetation are presented in Table 23. The fluoride concentrations in grass were generally below the level (30 ppm) of significance for ingestion by cattle,[11] the most sensitive species of livestock. A relatively high concentration of fluoride was measured at Station VS-2. Since this measurement is inconsistent with other fluoride data, it is expected that follow-up sampling will determine that this high value may be due sampling and/or analytical error.

Soil – Soil samples are collected annually from near the Perimeter Air Monitoring Stations, Figure 1. Nine samples, approximately three inches in diameter and one centimeter thick, are collected in a one-square-meter area at each location, composited, and analyzed radiochemically for uranium and plutonium content to determine background information for future comparison in event of an accidental release.

Data on uranium and plutonium concentrations in soil are given in Table 24. The plutonium concentrations found were comparable to the value of 0.05 pCi/g considered to be a representative concentration of plutonium in U. S. surface soil.[12]

Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge complex was defined as the perimeter of the ERDA-controlled area.

Gaseous effluents are discharged from several locations within each of the three Oak Ridge facilities. For calculational purposes, the gaseous discharges are assumed to occur from only one vent from each site. Since the release points at ORGDP and the Y-12 Plant do not physically approximate an elevated stack, their discharges are assumed to be from ground level; releases from HNL are through elevated stacks. The meteorological data collected at the HNL Tower Shielding Facility were assumed to be valid for all facilities. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 50 miles from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[13] and Gifford[14] incorporated in a computer program.[15] The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission.[16] The deposition velocities used in the calculations were 10^{-6} cm/sec for krypton and xenon, 10^{-3} cm/sec for tritium, and 1 cm/sec for particulates and iodine.[17]

Potential pathways of exposure to man from radioactive effluents released by the Oak Ridge operations that are considered in the dose estimates are presented in Figure 6. The pathways shown in the figure are not exhaustive, but they include the principal pathways of exposure based on experience.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and data presented in publications of the International Commission on Radiological Protection,[18-23] other recognized literature on radiation protection,[24-26] and computer programs incorporating some of these models and data.[27, 28] Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments;" they are obtained by integrating over the assumed remaining lifetime (50 years) of the exposed individual.

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates of radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for pathways of exposure based on parameters applicable to an average adult.[18, 23] The population dose estimate (in man-rem) is the sum of the total body doses to exposed individuals within a 50-mile radius of the Oak Ridge facilities.

Maximum Potential Exposure at the Site Boundary – The point of maximum potential exposure to an individual on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky-shine" from the plot. A maximum potential whole body exposure of 280 mrem/yr was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 56% of the allowable standard.[1] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

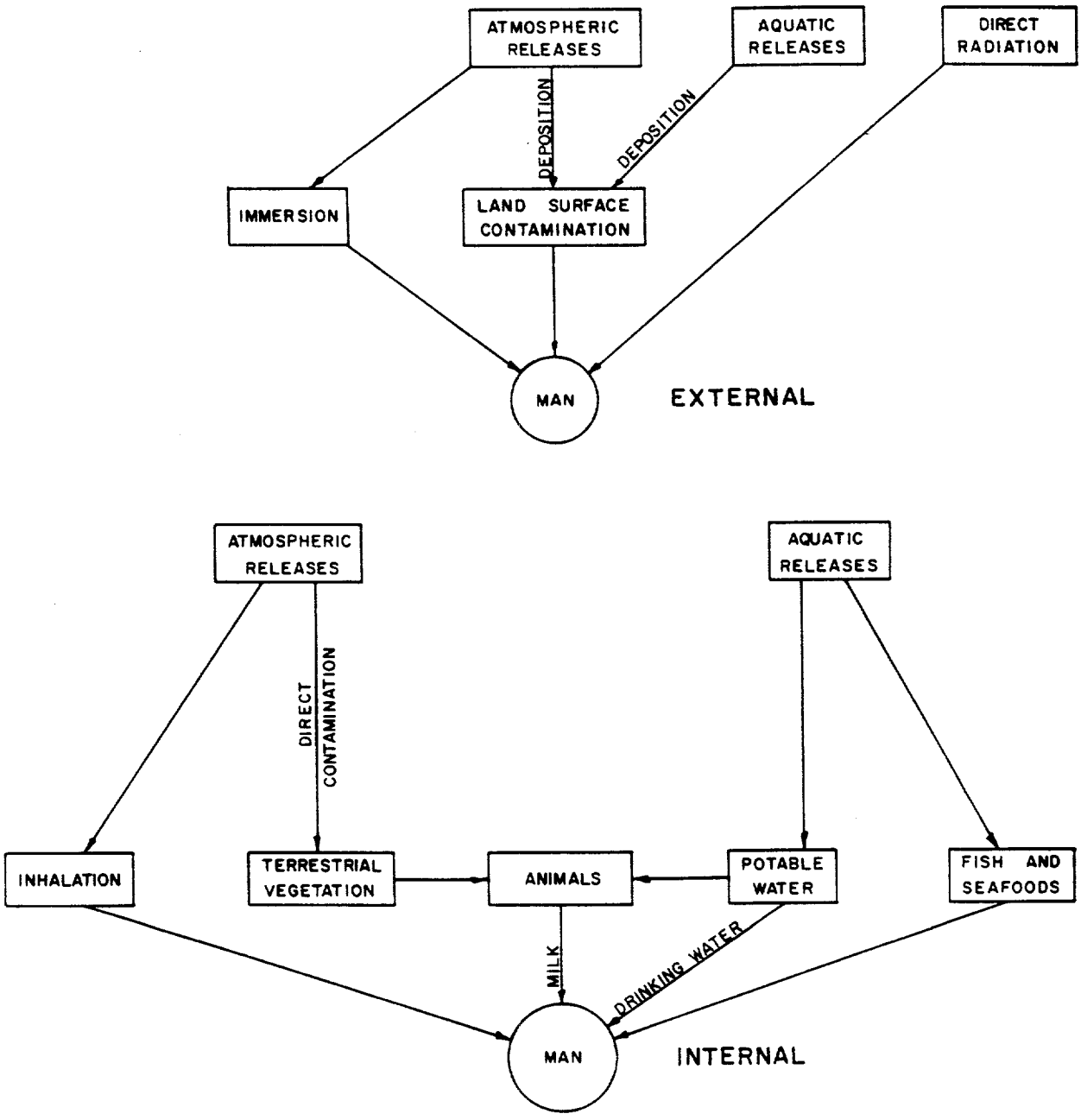

Figure 6

EXPOSURE PATHWAYS

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 7.7 mrem/yr which is 1.5% of the allowable standard[1] and represents what is considered a probable upper limit of exposure.

Other areas of radionuclide deposition have been reconfirmed and quantified along the river system, further downstream, by a survey made with the Aerial Radiological Measuring System (ARMS), but the radiation levels were all about an order of magnitude lower than those adjacent to the cesium plot.

A more probable exposure potential might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The maximum total body radiation dose from immersion to an individual residing continuously at the residence nearest HNL in the southwest direction is estimated to be 0.13 mrem/yr, or 0.03% of the allowable standard. The principal contributing radionuclide to this dose is ^{133}Xe.

An estimated annual radiation dose of 0.12 millirem to the total body of an individual continuously occupying the nearest residence northeast of the Y-12 facility is based on an inhalation rate[25] for an average adult of 2×10^4 liters/day. The lung is the critical organ for this pathway and would receive 4.8 millirem; uranium-234 is the important radionuclide contributing to this dose. These levels are 0.02% and 0.3%, respectively, of the allowable standards.

The most important contribution to dose for contamination within the terrestrial food-chain pathway is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Tables 20 and 21), indicate that the maximum dose to an individual in the immediate environs resulting from ingestion of one liter of milk per day is 0.35 millirem to the thyroid at Station Number 3, and 18 millirem to the bone at Station Number 6. Data collected at remote stations indicate that background radiation (i.e., weapons fallout) is responsible for virtually all of the dose from ^{131}I and at least 45% (8 millirem) of the dose from ^{90}Sr.

The distribution of ^{90}Sr around the Oak Ridge facilities is difficult to correlate with past releases (no ^{90}Sr was released in gaseous effluents during 1974) on the basis of meteorological calculations; the data do not show the trends expected, i.e., highest concentrations downwind and nearest the source point. A likely source is deposition from weapons fallout which is characteristically non-uniform. A twelve-month (August 1973–July 1974) average of ^{90}Sr concentrations in milk is reported by the U.S. Environmental Protection Agency[29] for milk stations throughout the conterminous United States. Twelve month average values range from 0 to 17×10^{-9} μCi/ml with an average of $5.6 \pm 3.3 \times 10^{-9}$ μCi/ml.

The public water supply closest to the liquid discharge from the Oak Ridge facilities is located approximately 16 miles downstream at Kingston, Tennessee. River water is used about 20% of the time to supplement spring water. Measurements of untreated river water samples at Kingston (see Table 9) indicate that the maximum dose resulting from the ingestion of 20% of the daily adult requirement (about two liters per day) is 0.55 millirem to the bone; ^{90}Sr present in the waters upstream of the Oak Ridge facilities accounts for 20% (0.11 millirem) of this dose. The resulting 0.44 millirem is about 0.1% of the standard.

Estimates of radiation dose to an adult were calculated for consumption of 37 pounds per year of fish from the Clinch-Tennessee River system.[10] This consumption is about 2.5 times the national average fish consumption[30] and is used because of the popularity of sport fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 22), the maximum dose to an individual is estimated to be 6.8 millirem to the bone from ^{90}Sr. Fish samples taken from Melton Hill Lake upstream were analyzed to determine background conditions. The results of the analysis were questionable, however, and are not included in this report. The activity per kilogram was higher than the activity per kilogram of fish taken downstream because of the small size of the fish and total weight of the samples analyzed; therefore, these data were not used in estimating dose. It is estimated from the analysis of upstream and downstream waters (see Table 9), that about 20% of the potential dose from fish is due to sources other than plant effluents.

Summaries are given in Table 25 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population – The Oak Ridge population received the largest average individual whole body dose as a population group. The maximum potential dose to an Oak Ridge resident was calculated to be 4.8 millirem to the lung. This calculated dose is 0.3% of the allowable standard.[1] The average total body dose to an Oak Ridge resident was estimated to be 0.004 mrem/yr as compared to approximately 100 mrem/yr from natural background radiation; the average dose to the lung of an Oak Ridge resident was 0.17 millirem.

The cumulative whole body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1974 plant effluents was calculated to be 10 man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation. About 25% of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Accumulation of radionuclides in the environment from past releases from the Oak Ridge facilities is difficult to distinguish from those arising from world-wide fallout, but it is estimated that the upper limit from past releases would be less than 25 man-rem.

Table 1
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Beta Activity of Particulates in Air
1974

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-13} μCi/ml			%
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	CG[c]
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	52	2.7	0.14	0.87 ± 0.08	0.09
HP-32	Midway Gate	52	2.9	0.13	0.92 ± 0.09	0.09
HP-33	Gallaher Gate	52	2.1	0.12	0.69 ± 0.06	0.07
HP-34	White Oak Dam	52	2.9	0.05	0.88 ± 0.09	0.09
HP-35	Blair Gate	52	2.9	0.05	0.95 ± 0.10	0.09
HP-36	Turnpike Gate	51	2.9	0.17	1.01 ± 0.10	0.10
HP-37	Hickory Creek Bend	51	1.6	0.13	0.66 ± 0.05	0.07
HP-38	East of EGCR	52	2.3	0.13	0.70 ± 0.07	0.07
HP-39	Townsite	52	2.7	0.10	0.88 ± 0.09	0.09
					0.84 ± 0.03	0.08
		Remote Area[e]				
HP-51	Norris Dam	50	1.8	0.15	0.74 ± 0.07	0.07
HP-52	Loudoun Dam	46	2.1	0.02	0.70 ± 0.07	0.07
HP-53	Douglas Dam	52	2.7	0.01	0.81 ± 0.08	0.08
HP-54	Cherokee Dam	51	3.2	0.18	1.03 ± 0.10	0.10
HP-55	Watts Bar Dam	49	2.5	0.13	0.91 ± 0.10	0.09
HP-56	Great Falls Dam	51	2.9	0.14	0.86 ± 0.09	0.09
HP-57	Dale Hollow Dam	52	2.5	0.07	0.91 ± 0.09	0.09
HP-58	Knoxville	50	2.9	0.11	0.75 ± 0.08	0.08
					0.84 ± 0.03	0.08

[a] Maximum weekly average concentration.

[b] Minimum weekly average concentration — minimum detectable level is 5×10^{-6} μCi per sample.

[c] CG is 10^{-10} μCi/ml for unidentified radionuclides (ERDA Manual, Appendix 0524, Annex A, Table II). During period of higher than normal activity, March to August, activity was identified as being due predominantly to ^{103}Ru, ^{95}Zn-^{95}Nb and ^{141}Ce. See text.

[d] See Figure 1.

[e] See Figure 2.

Table 2
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Alpha Activity of Particulates in Air
1974

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-15} μCi/ml			%
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	CG[c]
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	52	3.6	0.6	1.3 ± 0.11	0.03
HP-32	Midway Gate	52	5.3	0.7	1.6 ± 0.17	0.04
HP-33	Gallaher Gate	52	13.4	0.5	1.5 ± 0.26	0.04
HP-34	White Oak Dam	52	4.7	0.5	1.1 ± 0.12	0.03
HP-35	Blair Gate	52	9.5	0.5	1.6 ± 0.20	0.04
HP-36	Turnpike Gate	51	5.8	0.6	1.5 ± 0.14	0.04
HP-37	Hickory Creek Bend	51	3.0	0.5	1.0 ± 0.09	0.03
HP-38	East of EGCR	52	6.4	0.5	1.3 ± 0.15	0.03
HP-39	Townsite	52	5.2	0.6	1.3 ± 0.14	0.03
					1.4 ± 0.05	0.03
		Remote Area[e]				
HP-51	Norris Dam	50	3.2	0.5	1.1 ± 0.09	0.03
HP-52	Loudoun Dam	46	4.2	0.5	1.1 ± 0.10	0.03
HP-53	Douglas Dam	52	4.5	0.3	1.2 ± 0.11	0.03
HP-54	Cherokee Dam	51	3.4	0.5	1.2 ± 0.10	0.03
HP-55	Watts Bar Dam	49	4.9	0.2	1.3 ± 0.14	0.03
HP-56	Great Falls Dam	51	3.2	0.6	1.2 ± 0.11	0.03
HP-57	Dale Hollow Dam	52	4.9	0.5	1.3 ± 0.14	0.03
HP-58	Knoxville	50	3.2	0.5	1.3 ± 0.10	0.03
					1.2 ± 0.04	0.03

[a] Maximum weekly average concentration.

[b] Minimum weekly average concentration - minimum detectable level is 2×10^{-6} μCi per sample.

[c] CG is 40×10^{-13} μCi/ml for a mixture of Uranium Isotopes. (ERDA Manual, Appendix 0524, Annex A, Table II).

[d] See Figure 1.

[e] See Figure 2.

Table 3
CONCENTRATION OF ^{131}I IN AIR
AS MEASURED BY THE PERIMETER AIR MONITORING STATIONS[a]
1974

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-14} μCi/ml			% CG[d]
			MAXIMUM[b]	MINIMUM[c]	AVERAGE	
HP-31	Kerr Hollow Gate	52	2.5	0.3	0.9	<0.01
HP-32	Midway Gate	52	3.0	0.4	0.9	<0.01
HP-33	Gallaher Gate	52	1.8	0.3	0.7	<0.01
HP-34	White Oak Dam	52	3.0	<0.2	<0.8	<0.01
HP-35	Blair Gate	52	2.2	<0.2	<0.8	<0.01
HP-36	Turnpike Gate	52	2.8	<0.2	<0.7	<0.01
HP-37	Hickory Creek Bend	52	3.8	0.3	0.7	<0.01
HP-38	East of EGCR	52	4.0	0.3	0.8	<0.01
HP-39	Townsite	52	3.0	0.3	0.7	<0.01
Average					<0.8	<0.01

[a] See Figure 1.

[b] Maximum weekly average concentration.

[c] Minimum weekly average concentration—minimum detectable amount of ^{131}I is 3×10^{-6} μCi per sample.

[d] CG is 1×10^{-10} μCi/ml (ERDA Manual, Appendix 0524, Annex A, Table II).

Table 4

DISCHARGES OF RADIOACTIVITY TO THE ATMOSPHERE

1974

RADIONUCLIDE	CURIES DISCHARGED
Uranium[a]	0.13
^{131}I	2
^{3}H	555
^{133}Xe[b]	< 97,000
^{85}Kr[b]	< 20,000
^{99}Tc	0.3
Pu[c]	4×10^{-6}

[a] Uranium of varying enrichments – curie quantities calculated using the appropriate specific activity for material released.

[b] Upper limit values based on direct radiation instrument measurements in the stack gas stream and an assumed mixture of noble gases.

[c] Mixture of all isotopes.

Table 5

AIR MONITORING DATA – FLUORIDES

1974

LOCATION[a]	NUMBER OF SAMPLES[b]	MAX. 24-HOUR SAMPLE (ppb)	TIMES 24-HOUR STANDARD[c] EXCEEDED	MAXIMUM 30-DAY AVERAGE (ppb)	TIMES 30-DAY STANDARD[c] EXCEEDED	ANNUAL AVERAGE (ppb)
F-1	49	2.0	0	1.4	0	0.9 ± 0.1
F-2	52	7.4	3	2.7	3	1.3 ± 0.3
F-3	50	6.9	3	2.4	3	1.3 ± 0.4
F-4	52	9.8	3	2.6	4	1.3 ± 0.4
F-5	52	4.5	2	2.4	3	1.1 ± 0.3
F-6[d]	50	4.8	3	3.0	4	1.3 ± 0.3

[a] See Figure 1.

[b] Sample duration – 24 hours.

[c] Tennessee Air Pollution Control Regulations –

4.5 ppb for 12 hour averaging interval
3.5 ppb for 24 hour averaging interval
2.0 ppb for 7 day averaging interval
1.5 ppb for 30 day averaging interval

All values are maximum – not to be exceeded more than once per year.

[d] Station F-6 is approximately 5 miles from ORGDP in upwind direction of the prevailing winds, thus may be considered representative of general ambient background concentration.

NOTE: Data not amenable to comparison with 12 hour and 7 day standards.

Table 6
AIR MONITORING DATA – SUSPENDED PARTICULATES
1974

LOCATION[a]	NUMBER OF SAMPLES	CONCENTRATION, $\mu g/m^3$			% STD.[b]
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	24	91.2	10.5	47.8 ± 9.6	64
SP-2	20	133.1	14.1	46.4 ± 13.1	62
SP-3	25	101.7	8.4	40.9 ± 8.1	55
SP-4	24	67.1	9.4	43.7 ± 9.1	58

[a] See Figure 1.

[b] Tennessee Air Pollution Control Regulations – Primary standard based on annual geometric mean is 75.0 $\mu g/m^3$.

Table 7
SULFUR DIOXIDE MONITORING DATA
(Station S-1)
1974

MONTH	MAXIMUM 24 HOUR AVERAGE ppm	MONTHLY AVERAGE ppm
January	0.040	0.019
February	0.049	0.03
March	0.047	0.02
April	0.018	0.009
May	0.069	0.01
June	0.030	0.009
July	0.028	0.009
August	0.030	0.01
September	0.045	0.012
October	0.029	0.01
November	0.039	0.01
December	0.028	0.01
Annual Arithmetic Mean		0.013

Tennessee Ambient Standards.

Maximum 24 hr. Average — 0.14 ppm.
Annual Arithmetic Mean — 0.03 ppm.

Minimum Detectable Limit — 0.005 ppm.

Table 8
EXTERNAL GAMMA RADIATION MEASUREMENTS
1974

STATION NUMBER	LOCATION	BACKGROUND μR/hr
	Perimeter Stations[a]	
HP-31	Kerr Hollow Gate	8.6
HP-32	Midway Gate	10.0
HP-33	Gallaher Gate	8.0
HP-35	Blair Gate	6.9
HP-36	Turnpike Gate	7.2
HP-37	Hickory Creek Bend	7.1
HP-38	East of EGCR	6.9
Average		7.8
	Remote Stations[b]	
HP-51	Norris Dam	5.1
HP-52	Loudoun Dam	6.1
HP-53	Douglas Dam	6.9
HP-54	Cherokee Dam	7.1
HP-55	Watts Bar Dam	5.8
HP-56	Great Falls Dam	5.9
HP-57	Dale Hollow Dam	6.8
HP-58	Knoxville	9.8
Average		6.7

[a] See Figure 1.

[b] See Figure 2.

Table 9

RADIONUCLIDES IN THE CLINCH RIVER

1974

LOCATION	NUMBER SAMPLES	RANGE	CONCENTRATION OF RADIONUCLIDES OF PRIMARY CONCERN UNITS OF 10^{-9} μCi/ml				% CG[c]
			^{90}Sr	^{137}Cs	^{106}Ru	^{3}H	
C-2 CRM 23.1[a]	4	Max.	0.14	0.05	0.14	1180	
		Min.	0.05	<0.01	0.09	680	
		Avg.	0.09 ± 0.02	<0.03 ± 0.01	0.10 ± 0.01	930 ± 69	<0.06
CRM 20.8[b]	12	Max.	1.60	0.43	0.17	3260	
		Min.	0.46	0.06	<0.01	340	
		Avg.	0.89 ± 0.03	0.16 ± 0.01	<0.04 ± 0.01	1150 ± 71	<0.36
C-3 CRM 14.5[a]	4	Max.	1.09	0.05	0.14	2410	
		Min.	0.23	0.05	0.09	1000	
		Avg.	0.58 ± 0.11	0.05 ± 0.0	0.13 ± 0.01	1620 ± 169	0.26
C-5 CRM 4.5[a]	4	Max.	1.18	0.14	0.36	2130	
		Min.	0.14	0.05	0.23	770	
		Avg.	0.45 ± 0.14	0.08 ± 0.01	0.31 ± 0.02	1240 ± 185	0.21

[a] Measured values in the Clinch River.

[b] Values given for this location are calculated values based on the concentrations measured at White Oak Dam (Station W-1) and the dilution afforded by the Clinch River. They do not include radioactive materials (e.g., fallout) that may enter the river upstream of White Oak Creek outfall (CRM 20.8).

[c] Most restrictive concentration guide for each isotope used for calculating percent concentration guide. The method for calculating percent of concentration guide for a known mixture of radionuclides is given in ERDA Manual, Appendix 0524, Annex A.[1]

Table 10
URANIUM CONCENTRATION IN SURFACE STREAMS
1974

STATION NUMBER[a]	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-8} μCi/ml			% CG[b]
			MAXIMUM	MINIMUM	AVERAGE	
P-1	Poplar Creek	11	14.0	0.6	3.2 ± 2.7	0.1
P-2	Poplar Creek	11	5.3	0.3	2.1 ± 1.1	<0.1
C-3	Clinch River	11	1.0	0.1	0.5 ± 0.2	<0.1
C-4	Clinch River	11	0.7	0.1	0.3 ± 0.1	<0.1
E-1	East Fork Poplar Creek	12	14.6	2.4	6.3 ± 2.4	.2
B-1	Bear Creek	12	14.1	2.5	5.6 ± 2.4	.2

[a] See Figure 3.

[b] CG is 3×10^{-5} μCi/ml for a mixture of uranium isotopes (AEC Manual, Appendix 0524, Annex A, Table II).

Table 11
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1974

RADIONUCLIDE	CURIES DISCHARGED
^{140}Ba	0.05
^{144}Ce	0.02
^{137}Cs	1.2
^{60}Co	0.6
^{3}H	8600
^{131}I	0.2
^{106}Ru	0.2
^{90}Sr	6
^{95}Zr - ^{95}Nb	0.02
^{99}Tc	3.5
Uranium[a]	1.5
^{232}Th	0.02
Transuranics[b]	0.02

[a] Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b] Value based on gross transuranic alpha emitter analysis.

Table 12

CHEMICAL WATER QUALITY DATA – WHITE OAK DAM

(Location W-1, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.	
Zn	12	0.01	< 0.005	< 0.006 ± 0.002	5[a]	< 0.1
Cr	12	0.2	< 0.005	< 0.07 ± 0.04	0.05[a]	< 140
NO_3	12	11	0.8	3.1 ± 2.7	45[a]	7
Hg	12	0.001	< 0.0001	< 0.0004 ± 0.0005	0.005[b]	< 8

a U. S. Public Health Service Drinking Water Standards.

b Proposed EPA Standard.(31)

NOTE: Stream not a source of drinking water. Drinking water standards used for water quality comparison only.

Table 13

CHEMICAL WATER QUALITY DATA – MELTON HILL DAM

(Location C-2, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.	
Zn	11	0.01	< 0.005	< 0.006 ± 0.004	5[a]	< 0.1
Cr	11	0.02	< 0.005	< 0.01 ± 0.006	0.05[a]	< 20
NO_3	11	2	< 0.04	< 0.8 ± 0.7	45[a]	< 2
Hg	11	0.002	< 0.0001	< 0.0004 ± 0.0006	0.005[b]	< 8

[a] U. S. Public Health Service Drinking Water Standards.

[b] Proposed EPA Standard.[31]

Table 14

CHEMICAL WATER QUALITY DATA – ORGDP SANITARY WATER PUMPING STATION

(Location C-3, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.05	< 0.005	< 0.009 ± 0.008	0.01	< 90
Cl^-	11	10	1.6	4.3 ± 1.6	250	2
Cr	12	0.01	< 0.005	< 0.006 ± 0.001	0.5	< 12
CN	11	0.002	< 0.001	< 0.001 ± 0.0003	0.01	< 10
NO_3^-	11	7.2	0.2	2 ± 1.4	45	4
Pb	12	< 0.02	< 0.02	< 0.02	0.05	< 40
$SO_4^{=}$	11	7	4	5.2 ± 0.6	250	2
T.D.S.	11	210	98	128 ± 22	500	26
Zn	12	0.28	0.02	0.1 ± 0.05	5	2
F^-	12	0.2	0.006	0.08 ± 0.03	1.2	7

[a] U. S. Public Health Service Drinking Water Standards.

Table 15

CHEMICAL WATER QUALITY DATA – ORGDP RECIRCULATING WATER PUMPING STATION

(Location C-4, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cl^-	12	8	1.8	4.4 ± 1.1	250	2
Cr	12	0.02	< 0.005	< 0.01 ± 0.004	0.05	<20
CN	12	0.004	< 0.001	< 0.002 ± 0.0006	0.01	<20
NO_3^-	12	93	0.5	12.3 ± 16.4	45	27
Pb	12	0.03	< 0.02	< 0.02 ± 0.002	0.05	<40
$SO_4^=$	12	9	2	5 ± 1	250	2
T.D.S.	12	152	108	132 ± 10	500	26
Zn	12	1.4	0.02	0.2 ± 0.26	5	4
F^-	12	0.1	0.02	0.06 ± 0.02	1.2	5

[a] U. S. Public Health Service Drinking Water Standards.

Table 16

CHEMICAL WATER QUALITY DATA – EAST FORK POPLAR CREEK

(Location E-1, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.	
Cd	12	0.012	< 0.002	< 0.005 ± 0.002	0.01[a]	< 50
Cl^-	12	22	7	10 ± 3	250[a]	4
Cr	12	0.05	< 0.01	< 0.02 ± 0.009	0.05[a]	< 40
F^-	12	1.5	0.8	1.1 ± 0.2	1.2[a]	92
Hg	12	< 0.0005	< 0.0005	< 0.0005	0.005[b]	< 10
NO_3^-	12	18	2	12 ± 3	45[a]	27
Pb	12	0.4	< 0.01	< 0.02 ± 0.006	0.05[a]	< 40
$SO_4^=$	12	53	28	39 ± 4	250[a]	16
T.D.S.	12	233	116	183 ± 18	500[a]	37
Zn	12	0.2	0.03	0.07 ± 0.03	5[a]	1

a U. S. Public Health Service Drinking Water Standards.

b Proposed EPA Standard.(31)

NOTE: Stream not a source of drinking water. Drinking water standards used for water quality comparison only.

Table 17

CHEMICAL WATER QUALITY DATA – BEAR CREEK

(Location B-1, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.008	< 0.002	< 0.004 ± 0.002	0.01	< 40
Cl^-	12	6	3	5 ± 3	250	2
F^-	12	0.8	< 0.02	< 0.4 ± 0.1	1.2	< 33
NO_3^-	12	274	9	61 ± 46	45	136
$SO_4^=$	12	22	15	16 ± 1	250	6
Zn	12	0.1	< 0.02	< 0.05 ± 0.02	5	< 1

[a] U. S. Public Health Service Drinking Water Standards.

NOTE: Stream not a source of drinking water. Drinking water standards used for water quality comparison only.

Table 18

CHEMICAL WATER QUALITY DATA – POPLAR CREEK ABOVE BLAIR BRIDGE

(Location P-1, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.005	< 0.005	< 0.005	0.01	< 50
Cl^-	12	17	3	8 ± 3	250	3
Cr	12	0.13	< 0.005	< 0.02 ± 0.02	0.05	< 40
CN	12	0.009	< 0.0005	< 0.003 ± 0.002	0.01	< 30
NO_3^-	12	24	0.7	6 ± 4	45	13
Pb	12	< 0.02	< 0.02	< 0.02	0.05	< 40
$SO_4^=$	12	32	4	12 ± 5	250	5
T.D.S.	12	390	84	162 ± 53	500	32
Zn	12	0.2	0.02	0.05 ± 0.03	5	1
F^-	12	0.3	0.01	0.1 ± 0.05	1.2	8

[a] U. S. Public Health Service Drinking Water Standards.

NOTE: Stream not a source of drinking water. Drinking water standards used for water quality comparison only.

Table 19

CHEMICAL WATER QUALITY DATA – POPLAR CREEK NEAR CLINCH RIVER

(Location P-2, Figure 3)

1974

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	< 50
Cl^-	12	8	1	5 ± 1	250	2
Cr	12	0.02	0.005	0.01 ± 0.004	0.05	20
CN	12	0.004	< 0.0005	< 0.002 ± 0.0006	0.01	< 20
NO_3^-	12	5	0.1	2 ± 0.9	45	4
Pb	12	0.03	< 0.02	< 0.02 ± 0.02	0.05	< 40
$SO_4^=$	12	25	2	9 ± 4	250	4
T.D.S.	12	312	100	149 ± 34	500	30
Zn	12	0.28	0.02	0.07 ± 0.05	5	1
F^-	12	0.3	0.01	0.1 ± 0.05	1.2	8

[a] U. S. Public Health Service Drinking Water Standards.

NOTE: Stream not a source of drinking water. Drinking water standards used for water quality comparison only.

Table 20

CONCENTRATION OF ^{131}I IN RAW MILK

1974

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARD[b]
		MAXIMUM	MINIMUM[a]	AVERAGE	
			Immediate Environs[c]		
1	49	1.3	< 0.45	< 0.47	FRC Range 1
2	49	1.8	< 0.45	< 0.48	FRC Range 1
3	50	2.2	< 0.45	< 0.51	FRC Range 1
4	42	1.0	< 0.45	< 0.48	FRC Range 1
5	49	1.4	< 0.45	< 0.49	FRC Range 1
6	48	1.4	< 0.45	< 0.49	FRC Range 1
7	49	1.5	< 0.45	< 0.47	FRC Range 1
Average				<0.49±0.01	FRC Range 1
			Remote Environs[d]		
51	10	0.45	< 0.45	< 0.45	FRC Range 1
52	10	1.3	< 0.45	< 0.52	FRC Range 1
53	7	1.7	< 0.45	< 0.75	FRC Range 1
54	10	3.8	< 0.45	< 0.87	FRC Range 1
Average				<0.65±0.09	FRC Range 1

[a] Minimum detectable concentration of ^{131}I is 0.45 x 10^{-9} μCi/ml.

[b] Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to 1 x 10^{-8} μCi/ml	–	Adequate surveillance required to confirm calculated intakes.
Range II	1 x 10^{-8} μCi/ml to 1 x 10^{-7} μCi/ml	–	Active surveillance required.
Range III	1 x 10^{-7} μCi/ml to 1 x 10^{-6} μCi/ml	–	Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[c] See Figure 4.

[d] See Figure 5.

Table 21

CONCENTRATION OF ^{90}Sr IN RAW MILK

1974

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARD[b]
		MAXIMUM	MINIMUM[a]	AVERAGE	
		Immediate Environs[c]			
1	48	15	2.1	3.5	FRC Range 1
2	49	3.9	0.8	2.6	FRC Range 1
3	49	5.7	1.1	3.3	FRC Range 1
4	40	7.9	1.4	4.0	FRC Range 1
5	49	8.1	3.2	5.5	FRC Range 1
6	48	13	3.3	6.0	FRC Range 1
7	42	9.3	1.3	3.3	FRC Range 1
Average				4.0±0.11	FRC Range 1
		Remote Environs[d]			
51	10	3.7	2.1	2.7	FRC Range 1
52	10	2.7	0.9	2.1	FRC Range 1
53	7	3.4	1.3	2.6	FRC Range 1
54	9	5.8	2.6	3.5	FRC Range 1
Average				2.7±0.28	FRC Range 1

[a] Minimum detectable concentration of ^{90}Sr in milk is 0.5×10^{-9} μCi/ml.

[b] Applicable FRC Standard, assuming 1 liter per day intake:

Range I	0 to 2×10^{-8} μCi/ml	—	Adequate surveillance required to confirm calculated intakes.
Range II	2×10^{-8} μCi/ml to 2×10^{-7} μCi/ml	—	Active surveillance required.
Range III	2×10^{-7} μCi/ml to 2×10^{-6} μCi/ml	—	Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[c] See Figure 4.

[d] See Figure 5.

Table 22

RADIONUCLIDE CONTENT OF CLINCH RIVER FISH

1974

SPECIES	NUMBER OF SAMPLES[a]	pCi/kg Wet Weight		ESTIMATED % MPI[b]
		^{90}Sr	^{137}Cs	
White Crappie	1	43	187	0.32
Carp	1	52	27	0.36

[a] Composite of ten fish in each species.

b Maximum Permissible Intake — Intake of radionuclides from eating fish is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question.

Table 23

VEGETATION SAMPLING DATA

1974

STATION NUMBER[a]	F^- CONCENTRATION[b] µg/g (ppm)		U (TOTAL) CONCENTRATION[b] µg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
VS 1	17	1	0.1	<0.1
VS 2	67	1	0.6	<0.1
VS 3	10	1	0.1	<0.1
VS 4	10	1	0.2	<0.1
VS 5	15	2	<0.1	<0.1
VS 6	11	4	<0.1	<0.1
VS 7	8	3	<0.1	0.3
VS 8	15	12	<0.1	0.6
VS 9	27	6	<0.1	<0.1
VS 10	14	41	<0.1	<0.1

[a] See Figure 1.

[b] Analytical results are on a dry weight basis.

NOTE: Applicable guides for flora have not been established. However, for comparison, the *American Industrial Hygiene Association Journal* for January-February 1969 (pp. 98-101) states that dairy cattle is the species of livestock most sensitive to fluorides in grasses. For comparative purposes the following fluoride concentrations and their effect on dairy cattle are given:

30 ppm	—	no adverse effects
30 to 40 ppm	—	borderline chronic
40 to 60 ppm	—	moderate chronic
60 to 110 ppm	—	severe chronic
above 250 ppm	—	acute

Table 24

SOIL SAMPLES FROM NEAR
PERIMETER AIR MONITORING STATIONS

1974

SAMPLING[a] LOCATION	NUMBER OF SAMPLES[b]	DRY SOIL[c] UNITS OF 10^{-8} μCi/g	
		PLUTONIUM (*a*)	URANIUM (*a*)
HP-31	1	2.9	81
HP-32	1	3.4	117
HP-33	1	2.3	50
HP-34	1	1.9	43
HP-35	1	2.5	45
HP-36	1	0.9	43
HP-37	1	1.8	99
HP-38	1	2.8	59
HP-39	1	2.9	113

[a] See Figure 1.

[b] Nine samples, approximately three inches in diameter and one centimeter thick, collected in a one-square-meter area at each location and composited for analysis.

[c] Applicable guides for soil contamination have not been established.

Table 25

SUMMARY OF THE ESTIMATED RADIATION DOSE
TO AN ADULT INDIVIDUAL DURING 1974 AT LOCATIONS OF MAXIMUM EXPOSURE
FROM GASEOUS AND LIQUID EFFLUENTS OF THE OAK RIDGE FACILITIES

PATHWAY	LOCATION	DOSE (MILLIREM)	
		TOTAL BODY	CRITICAL ORGAN
Gaseous effluents			
Direct radiation from air and ground	Residence nearest X-10	0.13	0.13 (total body)
Inhalation of contaminated air	Residence nearest Y-12	0.12	4.8 (lung)
Terrestrial food chains[a]	Milk sampling Station #6	0.16	10 (bone)
Liquid effluents			
Aquatic food chains	Clinch-Tennessee River system	0.18	5.4 (bone)
Drinking water[b]	Kingston, Tennessee	0.01	0.44 (bone)
Direct radiation along water, shores and mud flats	Downstream from White Oak Creek near Cs field plots	7.7	7.7 (total body)

Average background dose in the U. S.[32] 106 mrem/yr

[a] The dose may be due to weapons fallout (see text).

[b] Based on the analysis of raw (unprocessed) water; see text.

REFERENCES

1. ERDA Manual Chapter 0524.

2. Radiation Data and Reports, 15(6-12), June 1974 to January 1975.

3. Radiation Data and Reports, 15(10) October 1974.

4. Tennessee Air Pollution Control Regulations, Department of Public Health, Division of Air Pollution, Nashville, Tenn., December 1972.

5. W. M. Lowder, et al., *Indoor Radon Daughter and Radiation Measurements in East Tennessee and Central Florida*, HASL TM 71-8, March 1971.

6. Methods for Chemical Analysis of Water and Wastes, EPA Methods Development and Quality Assurance Laboratory, NERC, Cincinnati, Ohio.

7. U. S. Public Health Service Drinking Water Standards, Revised 1962, U. S. Department of Health, Education, and Welfare, Public Health Service Publication No. 956.

8. General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee, Tennessee Water Quality Control Board, Department of Public Health, Nashville, Tenn., as amended December 1971.

9. Background Material for the Development of Radiation Protection Standards, Staff Report of the Federal Radiation Council, Report No. 2, U. S. Government Printing Office, Washington, September 1961.

10. P. Bryan and C. E. White, "An Economic Evaluation of the Commercial Fishing in the TVA Lakes of Alabama during 1956," *Proc. Twelfth Annual Conference Southeastern Assoc. of Game & Fish Commissioners*, 1958 (pp. 128-132).

11. American Industrial Hygiene Association Journal, January – February 1969 (pp. 98-101).

12. Plutonium and Other Transuranium Elements: Sources, Environmental Distribution and Biomedical Effects, U. S. AEC, WASH-1359, December 1974.

13. F. Pasquill, *Atmospheric Diffusion*, D. Van Nostrand Co., Ltd., London, 1962.

14. F. A. Gifford, Jr., *The Problem of Forecasting Dispersion in the Lower Atmosphere*, U. S. AEC, DTI, 1962.

15. M. Reeves, III, P. G. Fowler, and K. E. Cowser, *A Computer Code for Routine Atmospheric Releases of Short-Lived Radioactive Nuclides*, ORNL-TM-3613, Oak Ridge National Laboratory, October 1972.

16. F. T. Binford, T. P. Hamrick, and B. H. Cope, *Some Techniques for Estimating the Results of the Emission of Radioactive Effluent from ORNL Stacks*, ORNL-TM-3187, 1970

17. (a) P. Voilleque, D. R. Adams, and J. B. Echo, "Transfer of Krypton-85 from Air to Grass," *Health Physics*, 19, 1970 (p. 835).

    (b) D. F. Bunch (ed.), *Controlled Environmental Radioiodine Tests*, Progress Report 2, IDO-12053, August 1966.

    (c) F. A. Gifford and D. H. Pack, "Surface Deposition of Airborne Material," *Nuclear Safety*, 3(4), June 1962 (p. 76).

18. Recommendations of the International Commission on Radiological Protection, ICRP Publication 2, Report of Committee II on Permissible Dose for Internal Radiation, Pergamon Press, London, 1959.

19. Recommendations of the International Commission on Radiological Protection, ICRP Publication 6, Pergamon Press, London, 1964.

20. Recommendations of the International Commission on Radiological Protection, ICRP Publication 10, Report of Committee IV on Evaluation of Radiation Doses to Body Tissues from Internal Contamination due to Occupational Exposure, Pergamon Press, London, 1968.

21. Recommendations of the International Commission on Radiological Protection, ICRP Publication 10A, Report of Committee II on the Assessment of Internal Contamination Resulting from Recurrent or Prolonged Uptakes, Pergamon Press, London, 1971.

22. Metabolism of Plutonium and Other Actinides, ICRP Publication 19, Report of Committee II, Pergamon Press, London, 1972.

23. Report on Reference Man, ICRP Publication 23, Report of ICRP Task Group, W. S. Snyder, Chairman, Pergamon Press, London, 1975.

24. G. J. Hine and G. L. Brownell (eds.), *Radiation Dosimetry*, Academic Press, New York, 1956.

25. K. Z. Morgan and J. E. Turner (eds.), *Principles of Radiation Protection*, Wiley, New York, 1967.

26. W. S. Snyder, L. T. Dillman, M. R. Ford, and J. W. Poston, "Calculations of Absorbed Dose to a Man Immersed in an Infinite Cloud of Krypton-85," *Noble Gases Symposium*, Las Vegas, Nevada, September 24-28, 1973 (in press).

27. W. D. Turner, S. V. Kaye, and P. S. Rohwer, *EXREM and INREM Computer Codes for Estimating Radiation Doses to Populations from Construction of a Sea-Level Canal With Nuclear Exploswes*, K-1752, CTC and ORNL, Oak Ridge, Tenn., September 1968.

28. D. K. Trubey and S. V. Kaye, *The EXREM III Computer Code for Estimating External Radiation Doses to Populations from Environmental Releases*, ORNL-TM-4322, December 1973.

29. Radiation Data and Reports, 15(12), December 1974 (p. 769).

30. Agricultural Statistics 1969, U. S. Department of Agriculture, U. S. Government Printing Office, Washington, 1971 (p. 588).

31. EPA Air and Water Pollution Proceedings, January 31, 1972.

32. The Effects on Populations of Exposures to Low Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, U. S. National Academy of Sciences, National Research Council, Washington, 1972.

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